considerable distance from the electrode or on a special electrode placed at the further end for this purpose. Commercially, arcs nearly eight yards long have been produced. The air passing up the tube through the arc thus becomes oxidised. Prof. Bernthsen showed such an arc about three-quarters of a metre long. It was struck in a glass tube which had a copper spiral running up its entire internal length, this being shown in a darkened room. The sight of Prof. Armstrong's lecture theatre at the Central Technical College crowded to suffocation was very striking. After the arc had been burning for about one minute, two large glass globes connected with the arc tube became filled with brown fumes of oxides of nitrogen.

Prof. Birkeland followed, and accentuated some points in connection with the Birkeland-Eyde process. Then Dr. N. Caro described the cyanamide process, and claimed that it was the cheapest method for the fixation of atmospheric nitrogen. It was easy to obtain ammonia directly from cyanamide, and, furthermore, a host of chemical products could be made by using cyanamide as a starting product.

Mr. E. R. Taylor read a paper of great interest upon national and international conservation of water-power, a subject which is attracting considerable attention in America. It will also be remembered that at the annual meeting of the British Science Guild Sir William Ramsay also brought this matter forward, and a committee was appointed by the Guild to consider the matter.

The pollution of sea-water was discussed in the hygiene section by Prof. Kenwood and Mr. F. N. Kay-Menzies. Edible sea shell-fish reared or deposited in the neighbourhood of our shores are often exposed to dangerously contaminated sea-water; it is also questionable whether bathing in such water is not dangerous. The bacteria of typhoid can survive for several days in sea-water, and coastal tides and eddies are capable of carrying sewage contamination several miles in the course of twenty-four hours.

Dr. M. Frenkel described a method for rendering motor-car escape gas odourless. The car is fitted with a special box containing platinised asbestos or platinised porous porcelain. The exhaust gases are made to pass through this box, and the contact of the air and malodorous gas with the catalytic platinum causes complete oxidation, and thus deodorisation.

On Friday afternoon, May 28, Prof. Halle, of France, and Prof. Paternò, of Italy, gave addresses to the whole congress. On Monday, May 31, Prof. O. N. Witt, of Germany, and on Tuesday, June 1, Sir Boverton Redwood also gave addresses to the combined sections of the congress.

The congress was attended by more than 4000 members, and the number of papers presented was very large. The attendance at the sectional meetings was quite extraordinary, many members attending their particular section from 10 in the morning to 1.30, and then from 4 to 6 in the evening, and listening to the reading of twenty or thirty papers ranging over the whole scope of the subject. In one section there were at 6 p.m. more than 100 members alert and eager for more.

The hospitality has always been a feature of these congresses, and the countries in which the congresses have been held have vied with each other in the entertainment of their guests. In this respect also the congress in London was not behindhand. The members were entertained by the Lord Mayor and Sheriffs at the Guildhall on Wednesday, May 26, and on May 27 a reception was held at the Foreign Office by Mr. Lewis Harcourt, M.P., on behalf of the Government. About two thousand invitations were sent out; and the company bidden to meet the delegates included the French, Russian, Austro-Hungarian, Spanish, American, and Japanese Ambassadors; the Portuguese, Netherlands, Belgian, Brazilian, Swedish, Chinese, Greek, Norwegian, and Danish Ministers; leading members of the Government and the Opposition; and others of social and political distinction. Though most of the foreign members of the congress were present, apparently no effort was made to bring together British men of science of distinguished eminence in all departments of scientific activity to meet them. The visitors must have been disappointed to find that the chief people present at the reception, other than actual members of the congress, were renowned for their political and diplomatic connections rather than by their position in the scientific world.

There was a great banquet at the Crystal Palace on May 28, which was held in the central transept, and to which nearly 2000 ladies and gentlemen sat down. The dinner was followed by speeches, which some heard, and then by a special display of fireworks, which all saw. On Saturday, May 29, the King received a deputation from the congress, who were accompanied by Sir Henry Roscoe (hon. president), Sir William Ramsay (acting president), and Mr. W. Macnab (hon. general secretary). The following delegates had the honour of being presented to the King by Sir Henry Roscoe:—Dr. W. H. Nichols (America), K.K. Regierungsrat F. Strohmer (Austria), Dr. François Sachs (Belgium), Mr. O. Kouanze (China), Prof. Leon Lindet (France), Prof. Otto N. Witt (Germany), Prof. E. Paternò (Italy), Prof. Kuhara (Japan), Dr. S. Hoogewerff (Netherlands), N. Tavildaroff (Russia), Prof. Pinerua y Alvarez (Spain), Prof. Arrhenius (Sweden), and M. F. Reverdin (Switzerland). On Saturday there was also a great garden-party at the Botanic Gardens, given by the ladies' committee, and in the evening a reception by the president of the Society of Chemical Industry. On Sunday and Monday there was a host of private parties, which absorbed nearly three thousand of the guests. Finally, on Tuesday, June 1, a reception was given at the Natural History Museum.

Such congresses cannot but help international goodwill and stimulate friendship between the nations. No jarring word was heard; delegates from all the civilised world fraternised, and each taught the other something of the work which is being done in their own country; friendly rivalry has been stimulated, and by means of the social functions they have learnt to know each other as friends. It is often said that international sport is a bond of friendship between the nations, but it often leaves heartburnings. The meeting of a congress such as this leaves behind no unpleasant feeling, but stirs enthusiasm and admiration for the work which our rivals are carrying out, and cements the nations in a manner which no number of Dreadnoughts can accomplish.

EDUCATION AND RESEARCH IN APPLIED CHEMISTRY.[1]

THE question of the training of industrial chemists, after having been dormant for some years, has again been raised, and it has now taken the more definite form of whether our universities should develop schools of applied chemistry. Let us look at the example of the engineering industries. There has been more coherence and solidarity and more personal interest on the part of the leaders of the engineering profession with regard to technical education than has been shown by chemical manufacturers. The practical effect is that the term "technical education" in Great Britain has become almost synonymous with training in engineering, and on the governing bodies of the newer institutions the engineering influence is predominant. The lack of active interest in the educational side of applied chemistry on the part of the manufacturers has acted detrimentally to their own cause. The teachers, if left alone by the manufacturers, are apt to become too purely bookish, and the manufacturers, if they cut themselves adrift from the academic side of chemistry, are likely to become too narrowly practical. The recent discussions upon the desirability of the better training of industrial chemists have centred round the universities, and the technical schools and technical colleges have been passed over.

Definition of Terms.

In many cases where the education of the technical or industrial chemist has been under discussion, the manufacturers on the one hand, and the teachers on the other, have had in view totally different kinds of people. When the training of an industrial chemist is under discussion, do we mean his preparatory general scientific education, or that *plus* something more? If the latter, what is that "something more" to be? The manufacturers who ex-

[1] From the presidential address delivered before the Society of Chemica Industry on May 26, by Prof. Raphael Meldola, F.R.S.

pected the new technical education movement to staff their works with expert technologists underestimated the complexity of their own industries. Those teachers, on the other hand, who are clamouring for the staffing of our factories by scientifically trained chemists, as distinguished from technologists, have damaged their case by leaving out of consideration the expert technologist altogether—the man whose knowledge of *technique* enables him to translate a discovery into pounds, shillings, and pence. The education of the "chemical technologist" is of the same importance for chemical industry as the education of the "pure" chemist. Highly competent scientific chemists are as inseparable from the "technologist" or the "chemical engineer" or the "practical manufacturer" as were the Siamese twins from one another. Severance is death to both; and the manufacturers cannot afford to leave out of account the scientific chemist any more than the teachers can afford to ignore the technologist. In these discussions on education the teachers have had in mind the research chemist and the manufacturers the chemical engineer. The research chemist ought to be producible from the universities and technical colleges. With respect to the chemical technologist, the question is whether he can be produced under any of our existing educational curricula, or whether the factory is the only proper training ground.

The Works Chemist.

So long as we know what kind of student we are talking about there need be no confusion. The research chemist is a man who has received the highest possible training as a scientific chemist, and whose resourcefulness has been developed by prolonged systematic research. It is immaterial whether he receives his training in a university or in an efficient technical college. When we come to the consideration of the chemical technologist there must be more discrimination between the different branches of chemical industry before the conflicting views of teachers and manufacturers can be brought into harmony. The requirements of a chemical factory may be thus classified:—

(1) Research for the discovery of new products, or of new processes for producing known substances, or for the improvement of processes already being carried on.

(2) Supervision of the factory operations with respect both to plant and products; the valuation of the raw materials and finished products; the testing of intermediate products.

(3) A knowledge of the markets with respect to the supply and cost of raw materials and the demand for the finished products.

The "works chemist," or technologist, must be qualified to come under category No. 2, with (possibly) an incursion into the domain of No. 1. By the "works chemist" (excluding the analyst, the mechanic, and the workman) I mean a chemist with more or less knowledge of the general principles of engineering as applied to chemical factory plant. He cannot be too much of a chemist, and the more he is of an engineer the more competent will he be to discharge his duties. Where is this combination of qualifications to be acquired? I consider the question first from the point of view of the technical college.

Theoretical and Practical Instruction.

We have to deal with the student who is entering the technical institution for a systematic three years' course with the view of his becoming a chemical technologist. We much prefer that the student should come to us with no previous school training in science, which is generally too shallow to be of use, and stiffens the mental attitude to the point of conceit, though there is no reason why school science should not be taught in such a way as to make it of preparatory value. In the technical college we have to begin from the beginning. The subjects which, in addition to chemistry, are indispensable for the future chemical technologist are mathematics, physics (including electricity), and mechanics (including drawing-room practice). It takes at least two years to lay an elementary foundation in these subjects; there is left but one year for advanced instruction. This course is not more than a preliminary training; it cannot pretend to add to the scientific training that "something more" which is necessary for the technologist. There is no time for specialisation, and there are few technical schools in this country (exclusive of universities) where specialisation is possible. Can the technical education given in technical colleges be developed into technological training? Can the teaching in technical schools be made to approach the diversified requirements of the different branches of chemical industry so as to make the preparation for technology more effective? I believe it can, if we are prepared to give the necessary time. If I were unable to justify this belief, these newer institutions could not claim to be discharging any function differing from those discharged by educational establishments of all ranks, in which chemistry is taught for purely academic purposes.

Specialisation should follow upon the general training; but it is this specialised training which the manufacturer has in mind when he speaks of "technical" education. The chemical teaching of technical schools can be given a bias in the specialised direction without detracting from its value as an educational discipline and without damage to its theoretical treatment. Chemical manufacture consists in converting certain raw materials into useful products, with maximum yield and minimum expenditure. The systematic treatment of elements and compounds, say in the second- and third-year courses, can be developed in much greater detail in cases where technical products are concerned. There is as much pure scientific doctrine to be deduced from the study of useful products as from the study of useless products. By giving a technical bias to the teaching it is not proposed that technical chemistry, in the sense of chemical technology, which is a specialised subject, should be made a part of that preliminary training which up to this stage I have alone had under consideration. Why should not the "preparations" in the laboratories of the technical schools be made quantitatively? It gives zest to the work if the student is supplied with a known weight of raw material and given to understand that the value of his results will be estimated by the yield and purity of his product. A series of "preparations" might be arranged in which, not only the weight of the raw materials and of the final product were taken into consideration, but also the quantities of the various reagents used, and from these data, making sufficient allowance for the usual—*not* the laboratory—"working expenses," the actual cost of the product ascertained. I advocate the introduction of the large-scale practical exercise into the advanced stage of the preparatory training. The first difficulty the college-trained student has to face in the factory is his want of familiarity with large-scale operations.

With advanced students in the technical colleges the preparation work should be increased in scale so as to introduce an element of training in chemical handicraft. I am not now advocating the introduction of working models of special plant used in particular industries. The plea is for the handling of apparatus illustrating such general operations as are carried on in all factories—heating and cooling, evaporating, distilling, mechanical mixing, grinding, solution, filtration, &c., on something more than the ordinary laboratory scale. This plea does not mean that the colleges should be expected to teach chemical technology in the strict sense—that is a distinct question; nor that *all* preparation work should be done on this increased scale.

Chemical Technology.

The stage of technical chemistry should lead to that of chemical technology. Manufacturers ought not to be satisfied with the youth who has spent his three years at a technical school. The chemical technologist is a chemist *plus* a great deal more. The factory is not the proper place for beginning the technological training. During the supplementary period following the preparatory training in the technical school there should be opportunity for research work. The supplementary advanced or technological training should do for industrial chemistry what the post-graduate training does for academic chemistry—it should enable us to sort out the different orders of faculty. A few students would be found capable of development as research chemists, a larger number as

chemical technologists. The omission of research from our educational curricula means a loss to our industry of a class of chemical technologist of which we are in need—the man who has been trained in scientific habit of thought by the most effective of all known methods. In advocating the introduction of research into the advanced curriculum it must be most clearly understood that we are not contemplating the "research chemist" as defined in this address. He comes under another category. We are now considering only the higher education of the works chemist and the importance of research in relation to his advanced training. If it is admitted that some advanced training supplementary to the preparatory course is essential, and that science is to form part of that advanced training, the advanced laboratory work from the fourth year onwards could be made to include experimental investigation either in pure or applied chemistry.

The Sphere of the Chemical Technologist.

There appears to be a general opinion in favour of technological training. The proposals come chiefly from the university side, but that is immaterial. All attempts to move in this direction hitherto have been more or less paralysed by the teachers declaring for pure science and by the manufacturers proclaiming that it is impossible to teach chemical technology in the educational institutions. It is beginning to be perceived that when the technical education of the works chemist is under consideration it is really technological training that is meant. Chemical technology means generalised chemical engineering—a knowledge of the chemical, physical, and mechanical principles underlying the construction and working of the machinery and plant in general use in chemical industry. It is a composite subject, part of which is pure engineering, such as power production and distribution, and part of which is specialised engineering, such as the nature, source, and properties of the materials used in the construction of chemical plant.

There is practically no technical school in this country which provides a complete and coordinated course of training such as I have advocated. For the chemical industries, the technical education movement has been arrested just at that stage where the true technical training should begin. The technical institutions are not wholly, nor for the greater part, to blame; the manufacturers have not sufficiently encouraged them. The greater part of the chemical instruction in the technical institutions is carried on in evening classes. This kind of training is practically useless for industrial chemists. It would take the evening student nine years to complete the three years' preparatory course of the day student. At the same time, evening classes are of real value for men already engaged in the factory work—say foremen and managers who have had no training in scientific theory. After thirty years' technical education applied chemistry is lagging behind all other branches of technology.

The Universities as Schools of Applied Science.

While large numbers of institutions originally intended for instruction in applied science are carrying on purely scholastic courses, the universities, originally academic institutions, are now developing schools of applied science. Ought the universities to create departments of applied chemistry? If the ordinary graduate courses were not suitable for the chemical technologist they could be adapted without much difficulty. The university need only make provision for that kind of advanced work which I have advocated. It does not matter what kind of institution does the work so long as it is done efficiently; the need for it is great.

The Conclusion.

But if the higher work is to be taken over by the universities, the *raison d'être* of the technical school for chemical industry will become a thing of the past. It will be deplorable and wasteful if we find the university and the technical institution in the same town rivals instead of colleagues. The rational solution is that the technical institution should become a school of the university, as is the case at Manchester. Such a solution carries with it the implication that the technical institution will raise its technological teaching to the university standard. That is precisely what we want. In framing any educational policy of practical value for our subject the Society of Chemical Industry can play an important part. We are both imperial and international; we have the means of bringing together a body of expert knowledge and experience, both educational and technological, such as is possessed by no other organisation. An advisory or consultative education committee or board formed by our council from the ranks of our members, and comprising teachers and manufacturers, ought to be of such power that no departure in the technical training of chemists in any educational establishment, of whatever rank, could afford to neglect its counsels.

THE CAMPAIGN AGAINST MALARIA.[1]

MORE than nine years ago I had the privilege of addressing the Royal Institution (March 2, 1900) on the subject of my researches on the mode of infection in malarial fever, and I am now called upon to describe what has been done, or not done, in various countries to utilise for the alleviation of the disease the information then obtained.

The ancients appear to have recognised, not only the principal symptoms of malarial fever, but the fact that it is often connected with marshes; and more recently many authors ascribed this fact to the existence of poisonous vapours, which they supposed are given off by stagnant waters, or even by the soil. Still later, a series of pathological studies led to the discovery by Laveran in 1880 that the malady is produced by vast numbers of minute protozoal parasites of the red blood-corpuscles, and students of the subject now conjectured that these organisms originally inhabited the marshes, and infect man through air or drinking-water. My own studies, however, commenced eighteen years ago, and, confirmed and extended by many workers, showed that the parasites are carried from man to man by certain species of Culicidæ (gnats or mosquitoes), and that it is these carrying agents, and not the parasites themselves, which live in the marshes. Thus malarial fever was now proved to be merely a parasitic disease, the infection of which is carried from man to man by the agency of certain water-breeding insects.

As described in my previous lecture, the broad principles of this theorem were really fully established by the end of the year 1898. Although numerous minor details still required study—such as the precise species of mosquitoes which carry the infection in various countries, the exact habits of each species, and so on—yet I held that these questions could now be elucidated without difficulty in the ordinary course of work, and that we were already in a position to apply the discovery at once to the saving of human health and life. I propose, therefore, to take up the story again from this point.

First let me emphasise the great importance of this practical side of the subject. Malarial fever is spread over nearly the whole of the tropics, abounds in many temperate climates, and has been known to extend so far north as Sweden. In vast tracts of tropical Africa, Asia, America, and southern Europe almost every town and village is infested by it; millions of children suffer from it from birth to puberty; and native adults, though they tend to become partially immune, still remain subject to attacks of it. Although it is not often directly fatal, yet it is so extremely prevalent, so endemic in locality, so persistent in the individual, that the total bulk of misery caused by it is quite incalculable. More than this, its special predilection for the most fertile areas renders it economically a most disastrous enemy to mankind. Throughout tropical life it thwarts the traveller, the missionary, the planter, the soldier, and the administrator. From one-quarter to one-half the total admissions into military hospitals are returned as being due to it, and it is often the most formidable foe which military expeditions have to encounter. There are reasons for thinking that it indirectly increases the general death-rate of malarious countries by something like 50 per cent., and I venture to say that it has pro-

[1] Discourse delivered at the Royal Institution on Friday, May 7, by Prof. Ronald Ross, F.R.S.